Swift Observations of GRB 080607

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1 Introduction

BAT triggered on GRB 080607 at 06:07:27 UT (Trigger 313417) (Mangano *et al.*, *GCN Circ.* 7847). This was a 1.024 *sec* rate-trigger on a long burst with T_{90} = 80 *sec*. Swift slewed to this burst immediately and XRT began follow-up observations at $T + 82.1$ *sec*, and UVOT at $T + 100$ *sec*. Our best position is the UVOT location RA($J2000$) = $194.94665deg$ ($12h59m47.20s$), Dec($J2000$) = $+15.91965deg$ ($+15d55'10.74''$) with an error of 0.5 *arcsec* (90% confidence, including boresight uncertainties).

GRB 080607 has also been seen by Konus Wind (Golenetskii *et al.*, *GCN Circ.* 7862), by the Mini-Calorimeter (MCAL) on board AGILE (Marisaldi *et al.*, *GCN Circ.* 7866) and by INTEGRAL/SPI-ACS, confirming the bright, multi peak structure of the prompt emission reported in Mangano *et al.*, *GCN Circ.* 7847 (Beckmann, private communication).

The optical afterglow was detected by a number of ground based telescopes, e.g.: ROTSE III (Rujopakarn *et al.*, *GCN Circ.* 7846), Super-LOTIS (Updike *et al.*, *GCN Circ.* 7848), KAIT (Chornock *et al.*, *GCN Circ.* 7856), RTT150 (Zhuchkov *et al.*, *GCN Circ.* 7861), CrAO (Rumyantsev *et al.*, *GCN Circ.* 7891).

An infrared afterglow detection has been provided by PAIRITEL (Miller *et al.*, *GCN Circ.* 7850).

A redshift estimate z = 3.036 was provided by the Keck/LRIS based on the detection of a very strong, damped Lya profile and metal-line transitions of OI, SiII, CII, SiII* among others (Prochaska *et al.*, *GCN Circ.* 7849).

2 BAT Observation and Analysis

Using the data set from $T-240$ to $T+302$ *sec*, further analysis of BAT GRB 080607 has been performed by the Swift team (Stamatikos *et al.*, *GCN Circ.* 7852). The BAT ground-calculated position is RA($J2000$) = $194.964deg$ ($12h59m51.4s$), Dec($J2000$) = $+15.910deg$ ($+15d54'37.6$") $\pm$ 1.0 *arcmin*, (radius, systematic and statistical, 90% containment). The partial coding was 11%.

The mask-weighted light curves (Fig.1) show multiple peaks. The first starts at $\sim T-5$ *sec*. The main cluster of overlapping peaks starts at $\sim T-1$ *sec*, with the brightest peak at $T + 2.0$ *sec*, and ending at $\sim T + 10$ *sec*. Following that is a series of weak peaks out to $\sim T + 180$ *sec*. $T_{90}(15 - 350\ keV)$ is 79 ± 5 *sec* (estimated error including systematics).

The time-averaged spectrum from $T - 5.9$ to $T + 154.7$ *sec* is best fitted by a simple power-law model with photon index of 1.31 ± 0.04. The fluence in the $15 - 150$ *keV* band is $(2.4 \pm 0.0) \times 10^{-05}$ $ergs/cm^2$. The 1-sec peak photon flux measured from $T + 1.50$ *sec* in the $15 - 150$ *keV* band is 23.1 ± 1.1 $ph/cm^2/sec$. All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at http://gcn.gsfc.nasa.gov/notices_s/313417/BA/

3 XRT Observations and Analysis

Swift-XRT began follow-up observations of the field of GRB 080607 (trigger 313417, Mangano *et al.*, *GCN Circ.* 7847) on date 2008 June 07, 06:08:54 UT, 86 *sec* after the BAT trigger. The whole dataset

consists of 470 s in Windowed timing mode (from $T + 86$ *sec* to $T + 556$ *sec*) and ~ 77.6 *ksec* in Photon Counting mode (starting 556 *sec* after the trigger).

Using 3616 *sec* of overlapping XRT Photon Counting mode and UVOT data, we find an astrometrically corrected X-ray position (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue) of RA($J2000$) = $194.946417deg$ ($12h59m47.14s$), Dec($J2000$) = $+15.919333deg$ ($+15d55'09.6''$) with an error of 1.4 *arcsec* (90% confidence, including boresight uncertainties). This position is within 5.3 *arcsec* of the initial XRT position, and 1.4 *arcsec* from the optical afterglow candidate, reported by Schady *et al.*, *GCN Circ.* 7858.

The $0.3 - 10$ *keV* light curve (Fig.2) shows a complex behaviour. After an initial steep decay with slope 5.8 ± 0.4 we observe a double peaked flare, starting at $\sim T + 118$ *sec* and peaking at $T + 120$ *sec* and $T + 140$ *sec*. The underlying decay breaks at $T + 119^{+5}_{-2}$ *sec* to a slope of 1.7 ± 0.1. A second break at $T + (700 \pm 300)$ *sec*, followed by a slope of 1.5 ± 0.6, marks the beginning of a possible flare, interrupted by the orbital gap. The light curve behaviour after $T + 4000$ *sec* can be roughly described as a steep decay with slope -2.4 ± 0.1 with flares superimposed for instance at $\sim T + 6100$ *sec* and $\sim T + 25300$ *sec*.

The spectrum of the Windowed Timing data can be modeled by a absorbed power-law with photon index 1.81 ± 0.02 and an intrinsic NH column density of $(4.0 \pm 0.2) \times 10^{22} cm^{-2}$ at $z = 3.036$ (Prochaska *et al.GCN Circ.* 7849), in excess with respect to the Galactic value of $1.69 \times 10^{20} cm^{-2}$ (Kalberla et al. 2005). The average observed (unabsorbed) flux over $0.3 - 10$ *keV* for this spectrum (spanning a time of 86-556 *sec* after the trigger) is $2.9 \times 10^{-9} (3.0 \times 10^{-9})$ $ergs/cm^2/sec$.

The Photon Counting mode spectrum is also well modelled by an absorbed power-law with a photon index 2.1 ± 0.1 and an intrinsic column density of $(4.0 \pm 0.8) \times 10^{22} cm^{-2}$ at z=3.036, in excess with respect to the Galactic value. The average observed (unabsorbed) flux over $0.3 - 10$ *keV* for the time interval 568-1047 sec is $5.3 \times 10^{-11} (5.4 \times 10^{-11})$ $ergs/cm^2/sec$.

4 UVOT Observation and Analysis

The UVOT began observing the field of GRB 080607 92 seconds after the initial Swift BAT trigger (Mangano *et al.*, *GCN Circ.* 7847). The refined UVOT position is RA($J2000$) = $194.94665deg$ ($12h59m47.20s$), Dec($J2000$) = $+15.91965$ *deg* ($+15d55'10.74''$) ± 0.5 *arcsec* (90% confidence, including boresight uncertainties).

A faint afterglow is detected in the first white and v-band finding chart exposures only. This is consistent with the GRB being at a redshift of z=3.036, as reported in Prochaska *et al.GCN Circ.* 7849. The first white and v-band finding chart magnitudes with 1-sigma errors are given in Table 1, as well as the 3-sigma upper limits for co-added images from later observations.

Filter	T_{mid}(s)	Exp(s)	Magnitude/3-sig UL
wh	190.9	98.2	19.79 ± 0.13
wh	4806.9	510.6	> 22.07
v	594.6	393.5	19.44 ± 0.19
v	4048.5	300.2	> 20.11
b	5527.9	412.5	> 21.28
u	4934.2	432.2	> 20.93
uvw1	4934.2	432.1	> 20.80
uvm2	4745.1	432.1	> 20.57
uvw2	5745.6	358.5	> 20.83

Table 1: Magnitude limits from UVOT observations

where T_{mid} is the weighted mid time of the observation. The values quoted above are on the UVOT Photometric System (Poole et al, 2008, MNRAS 383,627). They are not corrected for the expected galactic reddening of E(B-V) = 0.02 in the direction of the burst (Schlegel et al. 1998).

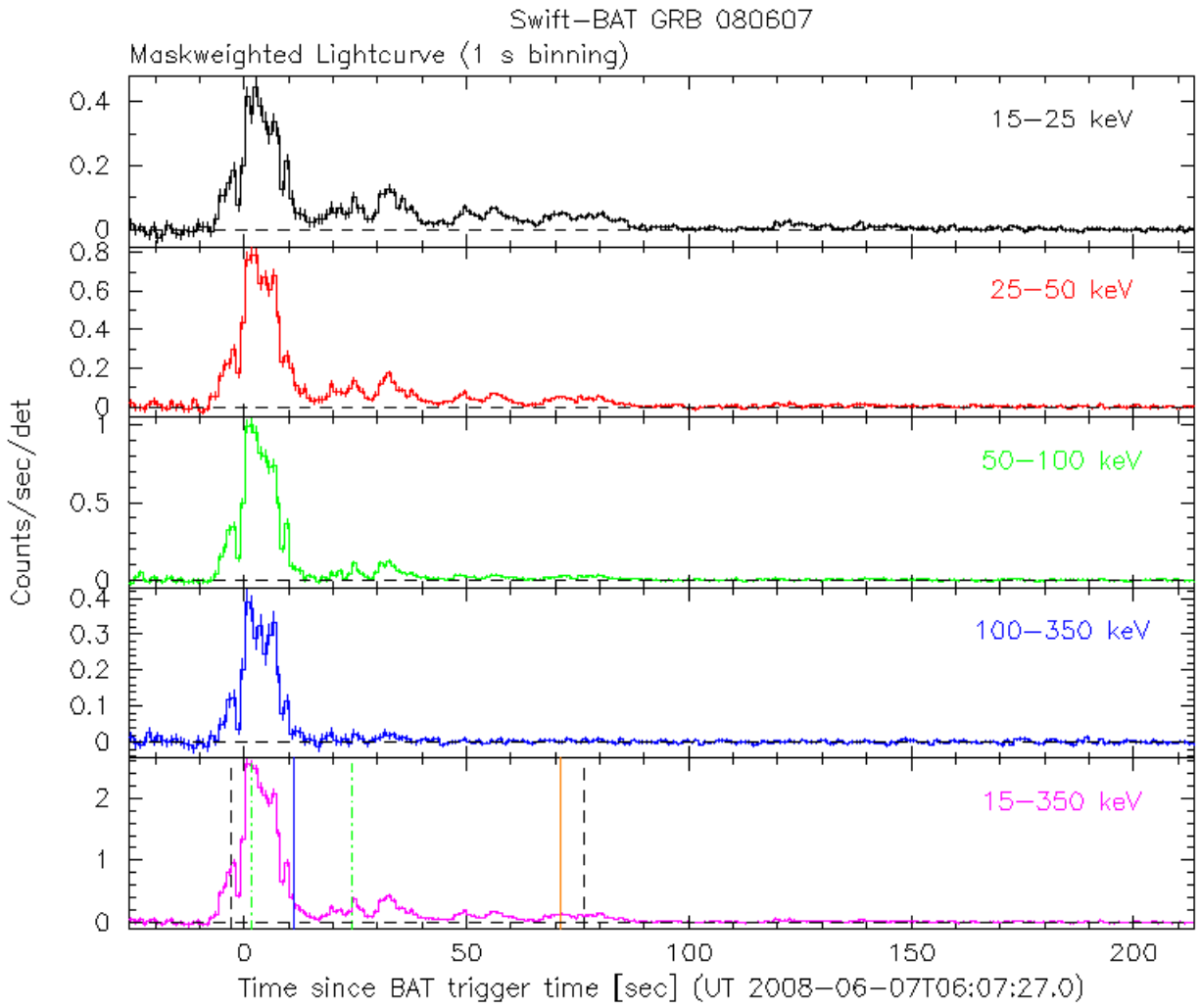

Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts s^{-1} illuminated-detector^{-1} (note illum-det = 0.16 cm^2) and T_0 is 2008-06-03 19:38:13 UT

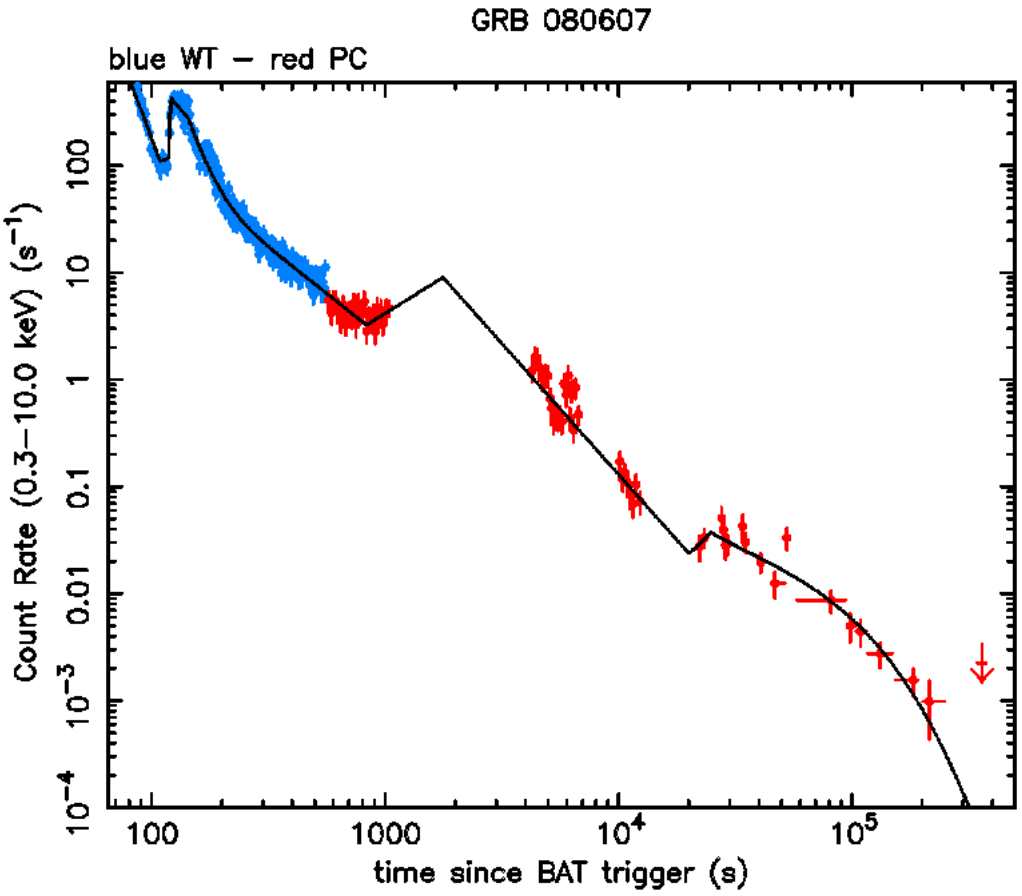

Figure 2: XRT Lightcurve. Counts/sec in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is 1 count/sec = $\sim 6.3 \times 10^{-11}$ $ergs/cm^2/sec$.